HIGHWAY POLICIES AND PROCEDURES MANUAL

	Maryland Department of Transportation **STATE HIGHWAY ADMINISTRATION** **Office of Highway Development** **Highway Design Division**	Director, Highway Development
Chapter	DESIGN	**Ref. No.**: D-90-07AL(H)
Section	ALIGNMENT (HORIZONTAL)	**Effective:**
Subject	DESIGN CONTROLS	**Sheet:** 1 **of** 5

Application: ☒ DESIGN
☒ CONSULTANT ENGINEERING
HYDRAULICS
☒ ENGINEERING SUPPORT
ADMINISTRATION
OTHER

Directive: The following guidelines establish the design procedures for selecting the horizontal alignment.

Alignment. Of all the various elements to consider when designing a new highway, the selections of the horizontal and vertical alignments are of greatest importance in establishing the character of the highway. Alignment affects the operating speeds, sight distance, capacity, and has a significant impact on safety operations of the highway. Once the line and grade are established, rarely can we afford to return and make significant improvements.

Coordination of Horizontal and Vertical Alignments. Horizontal alignment shall be designed in harmony with the vertical alignment. To analyze both alignments, a good practice is to superimpose the two alignments on the same mapping.

1. Horizontal and vertical tangents and curves shall be similar, with respect to position, length, and design speed.

2. Horizontal curves shall be slightly longer than the vertical curves.

3. Sharp horizontal curves shall not be introduced either at or near the crest of a pronounced vertical curve or at or near the bottom of a sag vertical curve. Both alignments shall be as flat as feasible on the approach to and at intersections, where sight distance along both roadways is important and vehicles may have to slow, turn or stop (Refer to 2001 ASHTO pages 283-285 for further data).

4. Short humps in the vertical alignment that tend to drop out of sight shall be avoided, whether on a horizontal curve or on tangent alignment.

5. Intersecting roadway connections shall not be tied in at the top of sharp crest vertical curves.

Horizontal Alignment. The horizontal alignment of a highway is defined as a series of straight-line tangents connected by horizontal curves. Factors that affect the mix of tangents and curves include terrain, right of way consideration, environmental impact, safety and economics.

General Controls. The principal factor controlling the horizontal alignment is the design speed. It is directly related to functional classification, intensity of development and terrain features.

Design speed establishes various basic criteria for certain design elements. Some of these elements are:

1. Maximum degree of curvature and superelevation.
2. Sight distance.
3. Roadway width.
4. Maximum gradients.

The elements of maximum degree of curve and sight distance are directly related to traffic safety and shall not be compromised.

The following general controls shall be considered in arriving at the final horizontal alignment.

Consistency.

1. Consistent design speeds in alignment selection shall always be sought.

2. Alignment shall be as directional as possible but consistent with the topography while considering improved properties and community values.

3. Winding alignment composed of short curves shall be avoided, as it is a cause of erratic operation.

4. Sharp curves shall not be introduced at the ends of long tangents or at the ends of long flat curves. Where sharp curvature is required, it shall be introduced by a series of progressively sharper curves.

5. Use of compound curves for mainline alignment shall be reserved for special restrictive conditions. Their use shall be avoided where curves are sharp.

   Compound curves with large differences in radii produce similar problems that exist with a tangent approach to a circular curve. Where compound curves are necessary, the radius of the flatter curve shall not be more than 50% greater than the radius of the sharper curve.

6. Reverse curves and broken-back curves on mainlines are discouraged.

   The use of transitional spirals shall be considered or adequate tangent length provided between the two curves so that proper superelevation could be obtained.

   Refer to Figure SE-3 "Minimum Length of Tangent Between Reversing Curves" in this chapter under subject "Guidelines For Use of Superelevation" for additional information.

7. When connecting intersecting roadways to the mainline alignment, particularly on crest vertical curves, careful consideration shall be given to assure adequate sight distance is provided.

Length of Curve. A horizontal curve is not required for central angles of 10 minutes or less. For small deflection angles, the horizontal curve length shall be long enough to avoid the appearance of a "kink." For central angles between 1 degree through 5 degrees, the minimum length of curve shall be 1000 feet. For angles less than 1 degree, the minimum length of curve may be 800 feet.

The minimum length of curve for 30 and 40 mph design on mainline highways shall be 15 times the design speed.

The minimum length of curve for design speeds of 50 mph and greater is 1000 feet.

Spirals. On mainline of expressways, the use of spiral curves is encouraged. The length of spiral is equal to the desired superelevation rate times the "C" factor (.0001 for expressways). Half level shall occur at the tangent to spiral point (TS) and again at the spiral to tangent point (ST). Full superelevation shall occur at the spiral to curve point (SC) and curve to spiral point (CS). Refer to Figure HA-1 on sheet 5 of 5 for additional information.

Superelevation. Refer to this chapter, section "Horizontal Alignments," subject "Guidelines for Use of Superelevation."

Bridges. It is advantageous for bridges to be located on tangent sections of the alignment. Often it becomes necessary to locate a bridge on a horizontal curve. In these instances, care shall be used to avoid beginning or ending a curve on a bridge.

Control Lines. Relationships between survey line, base line of construction and the profile grade line shall be clearly identified on the typical section sheets of the plans. The following general criteria should apply.

1. On two-lane roadways and undivided multilane roadways the centerline of survey, centerline of construction, profile grade line and the point where the profile grade elevation is applied shall be located at the center of the typical section.

2. On four lane divided highways with medians, 78 feet and less, the horizontal control shall be at the centerline of the median with a single profile grade. The profile grade elevation shall be applied at the median edge of pavement.

3. On multilane divided highways with relatively wide medians, independent horizontal and/or vertical controls can be established.

Sight Distance. In the design of a highway, there are four basic sight distances to be considered:

1. Stopping - Sight Distance for both crest and sag curves.
2. Passing Sight Distance.
3. Intersection Sight Distance.
4. Decision Sight Distance.

On tangents, the obstruction that limits the driver's sight distance is the road surface at some point on a crest vertical curve. On horizontal curves, the obstruction may be the road surface at a point on a crest vertical curve; or it may be some physical feature outside the traveled way such as longitudinal barrier, cut slope, trees, or foliage, etc. The designer shall check both vertical and horizontal planes for sight distance obstructions.

The designer shall review sight distance across the inside of curves to verify adequate sight distance. Parapet walls, cut slopes including vegetation, etc. may limit sight distance on curves. Where these obstructions can not be removed, adjustment to the normal cross-section or change in alignment may be required to assure adequate sight distance. Refer to page 228, 2001 AASHTO.

Intersection sight distance is the distance required for a driver on a roadway, in a stopped position, to safely depart and cross or enter into the traffic stream of another roadway without affecting safety of the entering vehicle or the vehicle of the other roadway. Refer to appropriate charts in 2001 AASHTO.

Stopping sight distances are usually sufficient to allow alert drivers to come to a stop under ordinary circumstances. However, these distances may be inadequate when:

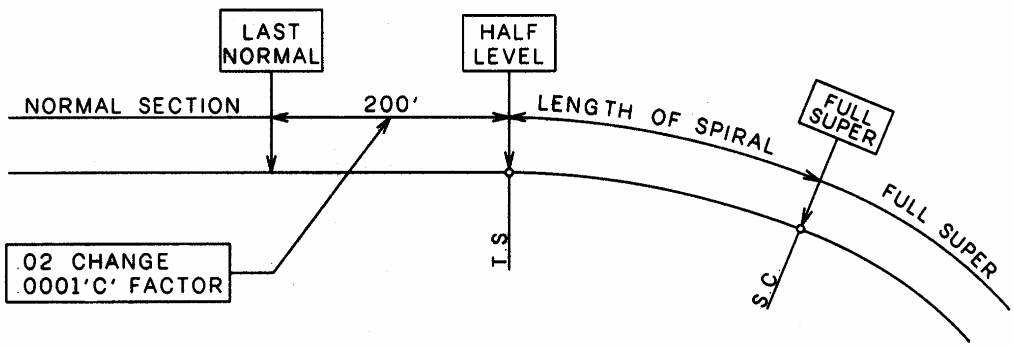
1. Drivers must make complex or instantaneous decisions.
2. Information is difficult to perceive.
3. Unexpected or unusual maneuvers are required.

Decision sight distance shall be considered where these conditions exist. Examples of possible consideration, where these kinds of driver error are likely to occur are:

1. Interchanges and intersections.
2. Locations where unusual or unexpected maneuvers are required.
3. Lane drops.

Where there is likelihood for error in understanding traffic control markings, decision making or driver actions, the decision sight distances shall be considered. If it is not feasible to provide the decision sight distance, special attention shall be given to the use of suitable traffic control devices for providing advance warning of the condition to be encountered.

DESIGN AND SUPERELEVATION OF SPIRAL CURVES FOR MAINLINE EXPRESSWAYS ONLY



LENGTH OF SPIRAL = SUPER RATE ÷ 'C' FACTOR

USING A 'C' FACTOR OF .0001, THE FOLLOWING LENGTHS APPLY:

WHEN S =	.08	- USE	800' SPIRAL
" "	.06	"	600' "
" "	.04	"	400' "
" "	.02	"	200' "

HALF LEVEL OCCURS AT THE T.S. and S.T. STATIONS
FULL SUPER EXTENDS FROM THE S.C. TO THE C.S. STATION.
NORMAL SECTION IS 200' BEYOND T.S. and S.T. STATIONS
(C = .0003)

REFER TO HICKERSON OR BARNETT BOOKS FOR SPECIFIC CURVE DATA. ALSO SEE COMPUTER UNIT PERSONNEL FOR SIMPLIFIED METHODS OF SETTING SPIRAL CURVES USING THE COMPUTER.

NOTE: SPIRAL WILL NOT BE USED ON INTERCHANGE RAMPS INCLUDING DIRECTIONAL RAMPS.

FIGURE HA-1